Evaluation of incompatible coadministration of continuous intravenous infusions in a pediatric/neonatal intensive care unit

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Abstract: OBJECTIVES: We aimed to evaluate and quantify incompatible coadministrations of continuous intravenous medication in the daily clinical practice of a PICU/NICU. METHODS: We conducted a retrospective, observational study in the setting of an 18-bed PICU/NICU. All concurrently administered continuous infusions, including blood products and parenteral nutrition, were analyzed for 2 months. Raw electronic data were retrieved and subjected to quality controls. Infusion combinations were classified as compatible, incompatible, no data, or variable according to the internal hospital charts, Trissel's database, and the Swiss summary of product characteristics. For situations with incompatible coadministrations, we assessed alternative distributions of infusions among the currently available lumen. RESULTS: Data for 100 patients were analyzed. Patients were exposed to a mean of 6.9 ± 3.6 individual continuous infusions administered through 3.8 ± 1.8 lumina. Among the 1447 coadministered continuous infusions, we detected 146 incompatible combinations (10%), resulting in 105 individually relevant incompatible situations. Furthermore, 185 combinations (13%) were not covered by internal compatibility charts, and for 207 combinations (15%) no data on compatibility were available. We found that 58% of the incompatible situations could have been avoided by a redistribution of the infusions among the available lumina. CONCLUSIONS: Most infusion combinations in the studied PICU/NICU were compatible and covered by the internal compatibility charts. However, we also identified concurrent administrations of incompatible infusions or for which compatibility data are not available. A significant reduction of coadministrations of incompatible infusions could be achieved through optimal use of available lumina.

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Evaluation of Incompatible Coadministration of Continuous Intravenous Infusions in a Pediatric/Neonatal Intensive Care Unit

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OBJECTIVES We aimed to evaluate and quantify incompatible coadministrations of continuous intravenous medication in the daily clinical practice of a PICU/NICU.

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CONCLUSIONS Most infusion combinations in the studied PICU/NICU were compatible and covered by the internal compatibility charts. However, we also identified concurrent administrations of incompatible infusions or for which compatibility data are not available. A significant reduction of coadministrations of incompatible infusions could be achieved through optimal use of available lumina.

ABBREVIATIONS MNIC, maximum number of infusion combinations; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit; PIM, pediatric index of mortality; PN, parenteral nutrition; SPC, summary of product characteristics

KEYWORDS incompatibilities; infusions; parenteral; PICU/NICU

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Introduction

Intravenous medication administration is a complex procedure involving several steps and is therefore prone to errors.[1,2] Moreover, critically ill children frequently need numerous drugs and other delicate infusions, including blood products or parenteral nutrition (PN), to be applied via a limited number of available lumina. However, to the best of our knowledge, no study has assessed the compatibility of coadministered continuous infusion considering PN and blood products in the setting of a PICU/NICU in daily clinical practice.

Incompatible coadministration of IV drugs may result in complications ranging from simple catheter obstruction to fatality.[3,4] Incompatibilities are caused by physical (precipitation, color change, gas production) or chemical (oxidation, reduction, hydrolysis, decomposition) reactions, usually occurring outside the body between 2 products.[5] Also, infants and children are at an increased risk for developing particulates because of the small size of their veins,[6] causing endothelial damage and inflammation leading to phlebitis or pulmonary embolism.[6,7] Although several cases of severe clinical outcomes due to incompatibility issues have been reported,[3,8–10] a recent French review of the literature covering adult and pediatric settings found that only limited data are available on this topic.[4] A previous Swiss study observed incompatibilities in 3.4% of the administered IV medication on a PICU,[11] and a recent Canadian analysis concluded that 9% of the concurrent

infusion administrations were incompatible.[12] Previous studies found that 10% to 50% of the drug combinations reported in previous studies were administered without compatibility data.[11,13,14] This lack of data on compatibility further compromises the patient's safety. In addition, the compatibility of PN and blood products remains largely unexplored and/or ambiguous and is therefore generally not recommended.[15,16]

Literature and our clinical experience suggest that patients on our PICU/NICU are occasionally exposed to incompatible coadministrations. Therefore, the aim of the present study was to assess the frequency and nature of incompatible coadministration of continuous infusions on our PICU/NICU. Furthermore, we presumed that incompatible coadministrations may be avoided if nurses and physicians are adhering to compatibility charts, provided they cover combinations occurring in clinical practice.

Because incompatibilities are administration errors, which have been demonstrated to be preventable by compatibility tools and/or the assistance of pharmaceutical services, the present study may contribute to the development and implementation of specific actions that increase patients' safety.[14,17,18]

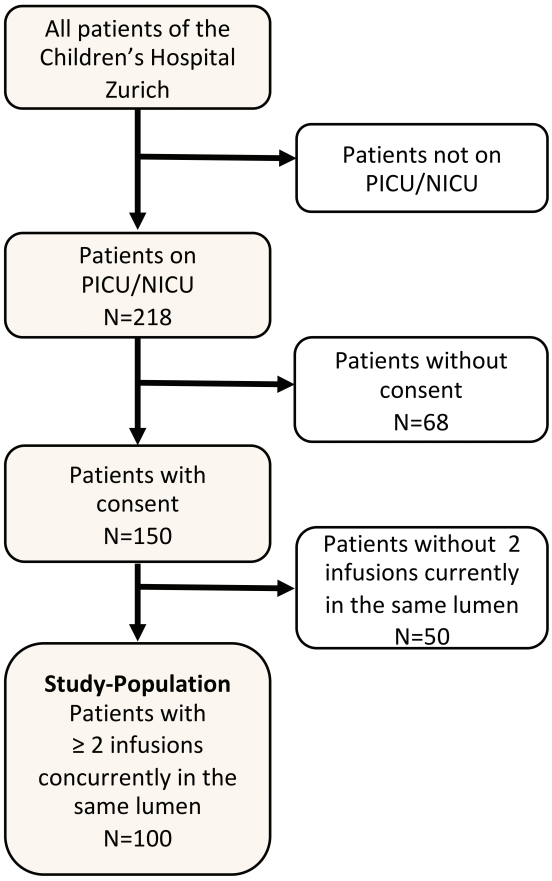
Methods

We conducted an observational, retrospective study in the PICU/NICU of the University Children's Hospital in Zurich. It features 18 beds and is dedicated to patients ranging from preterm babies to adolescents up to 16 years. All patients admitted to the PICU/NICU from February 4 to April 4, 2018, were included, with the exception of patients for whom the parents refused consent to use personal medical data for research purposes. Patients who did not concurrently receive at least 2 continuous infusions in the same lumen were also excluded, as depicted in Figure 1. Approval from the Swiss Ethics Committee was obtained before the start of the study.

Data was compiled daily in intervals from 2:00 p.m. to 1:59 p.m. based on electronic patient documentation. The primary source for all data in this study originated from the 2 clinical information systems used for patients hospitalized on the PICU/NICU. These software programs were Phoenix (version 7.14.0.5, CompuGroup, Bern, Switzerland), a clinical information system and MetaVision (version 5.46, iMDSoft, Tel Aviv, Israel), an intensive care unit patient-data management system.

A quality assessment to identify whether the electronic patient records corresponded to the actual distribution of the infusions among the available lumina was performed: As a quality control, the documentation of infusions in the clinical information systems was printed out and compared to the actual configuration of infusions and lumina at the bedside of the patients upon 8 unannounced occasions during different daytimes and weekdays.

Figure 1. Flowchart of patients included during the study period of February 4 to April 4, 2018.



Each combination of continuous infusions was considered (i.e., drugs, electrolyte solutions, PN, and blood products). Data on IV injections and infusions lasting less than 15 minutes were not considered because they were not sufficiently documented in the electronic medical records. The following patient parameters were anonymously recorded: sex, age, weight, length of stay, pediatric index of mortality (PIM) upon admission on the PICU/NICU, number of central venous catheters, the number of available IV lumina and all administered continuous infusions.

An infusion combination was defined as any combination of at least 2 infusions concurrently administered into the same lumen. Whenever 1 infusion was added (or removed if 2 or more infusions were combined) to any combination it was assessed as an additional combination. We then combined multiple related incompatible combinations into single incompatible situations, which are more representative of clinical practice: they represent potentially dangerous coadministrations of infusions that need to be addressed coincidentally. The compatibility checks for infusion combinations were

Table 1. Patient Characteristics

Parameter	Value
Patients included, n	100
Patient-days included, no. (%)	503 (50)
Mean no. of patients included per day	8.4
Male sex, n (%)	58 (58)
Age at admission, yr	
Mean ± SD	2.6 ± 3.9
Median (IQR)	0.9 (0.1–3.0)
Range	0.003–13
Age distribution of patients, n (%)	
0–3 yr	78 (78)
3.1–16 yr	22 (22)
Length of stay, days	
Mean ± SD	6.3 ± 8.2
Median (IQR)	3.0 (2.0–8.0)
Range	1–60
PIM at admission, %	
Mean ± SD	5.9 ± 11.4
Median (IQR)	2.5 (1.1–5.4)
Range	0.13–77.60

PIM, pediatric index of mortality

made pairwise using 3 different references. Primarily, combinations were verified using internal compatibility charts developed by the pharmaceutical services of the University Children's Hospital Zurich. These charts were compiled by interpreting several compatibility references (Trissel's database; manufacturer information, such as pH values; Swiss summary of product characteristics [SPC]). For commonly occurring combinations on which the Swiss SPC, Trissel's, or primary literature did not provide any data, the following principles were applied to develop the charts: combinations of IV medications were considered incompatible if their pH differed by a value of more than 2 or if any of the involved medications contained critical excipients, such as buffers or solubilizers. Any blood products or proteins were also generally considered incompatible with any other IV medication unless there was specific compatibility data available.

If infusion combinations did not feature on the internal compatibility charts, compatibility data in the Trissel's database (website of Micromedex) and the Swiss SPC were consulted for classification. Infusion combinations were classified in 4 categories: compatible, incompatible, no data, or variable (concentration-dependent). Likewise, all incompatible combinations classified as such based on the internal compatibility charts were rechecked in Trissel's database and the Swiss SPC. This recheck served to assess whether the incompatibility on the internal compatibility charts was also described elsewhere or if it was a recommendation based on the evaluation of the pharmaceutical services. Because compatibility databases provide only information for infusion pairs, the compatibility of a combination composed of more than 2 infusions was derived to be compatible if all infusion pairs were compatible. In cases with more than 2 concurrent infusions, for which there were different compatibility categories, the compatibility of any such combination was assessed as a combination in the highest risk-tier. All incompatible situations of this study were reviewed for a compatible alternative redistributing the infusions among the available lumina.

We developed a score to represent the maximum number of infusion combinations (MNIC) patients were exposed to during their stay. Associations of this MNIC score and further patient parameters (age, PIM, length of stay on PICU/NICU) with occurrence of an incompatible situation were analyzed with a logistic regression model in STATA (version 13.1, StataCorp, College Station, TX). For each parameter, patients were divided in quartiles. The quartiles with the largest number of patients were used as reference groups. Statistical significance was defined by $p < 0.05$, and relative risks were calculated with their 95% CIs.

Results

A total of 100 patients were included in this study contributing overall 503 patient-days for further analysis. Median age was 0.9 years, and 58% of the patients were male. Mean length of stay was 6.3 days and mean PIM for the included patients was 5.9%. Patients' characteristics are summarized in Table 1.

Our quality assessment of the documentation in the electronic medical records allowed the assessment of a total of 172 administrations among 44 individual patients. We identified 10 administrations of continuous infusions that were not correctly documented in the electronic patient record patient data management system, which corresponds to an error rate of 5.8% (3.0% to 10.7% using a 95% CI). Detailed data are displayed in Table 2.

Overall, we compiled data on 3949 individual infusions from which 1447 combinations of continuous infusions were considered for this study. On average, patients had 2.7 catheters and received a mean 6.9 ± 3.6 continuous infusions (range, 2–17) distributed among 4 lumina (range, 1–8) per day. The most frequently administered infusions were morphine (n = 437), followed by midazolam (n = 363) and saline solution 0.9% (n = 251). The most frequent combination of concurrently administered infusions through the same lumen was midazolam and morphine (n = 232). Detailed results are presented in Table 3 and Supplemental Table 1.

Among the recorded combinations, 1077 were composed of 2 concurrent infusions, and 370 combinations

Table 2. Quality of Documentation: Data of Samples

Sample	Date	Time	No. of Patients	Patients Included (With Consent)	No. of Infusions Controlled*	No. of Infusions Incorrectly Documented†
1	March 7, 2018	9:00 a.m.	6	4	26	4
2	March 8, 2018	9:00 a.m.	6	5	28	1
3	March 11, 2018	9:00 a.m.	6	4	24	0
4	March 11, 2018	12:00 p.m.	6	5	13	0
5	March 13, 2018	9:00 a.m.	7	4	21	1
6	March 13, 2018	9:00 a.m.	9	8	18	1
7	March 19, 2018	4:00 p.m.	8	7	18	1
8	March 20, 2018	10:00 a.m.	8	7	24	2
Total			56	44	172	10

* Comparing electronic documentation in pediatric database management system with actual distribution at bedside.
† Electronic documentation in pediatric database management system not corresponding to actual distribution at bedside.

(35%) consisted of 3 or more. A maximum number of 7 continuous infusions were concurrently administered in the same lumen. Using the internal compatibility charts, 146 combinations (10%) were classified as incompatible and 1061 (73%) as compatible. The compatibility of 185 combinations (13%) was not available on the internal compatibility charts and was therefore categorized using the database of Trissel's or the Swiss SPC. For 207 infusion combinations (15%) that were coadministered, no data about their compatibility were available in any reference (Table 4). For 15 combinations of infusions (1%), data on compatibility were conflicting (Supplemental Table 2). These ambiguous combinations were discussed between three members of the pharmaceutical services until they agreed on a classification to the best of their pharmaceutical knowledge.

A total of 146 incompatible infusion combinations (10%) classified in 105 incompatible situations were recorded during 60 days, and 46 patients (46%) were exposed to at least 1 incompatible situation. The internal compatibility charts covered all incompatible combinations. Among the 146 incompatible combinations, 11 (8%) were also classified as incompatible in the Trissel's database and/or in the Swiss SPC. For the 135 other combinations classified as incompatible in the internal compatibility charts there were no data available in Trissel's and/or the Swiss SPC. Among the incompatible combinations, the most frequently concerned infusions were blood products, which were present in 34%. Midazolam, morphine, and tranexamic acid were also frequently involved in incompatibilities. Tranexamic acid with midazolam was the incompatible combination that occurred most frequently. Among the combinations administered without data on compatibility, the most frequent combination was morphine with a mixed solution containing glucose (9.1%) and sodium chloride (0.9%). A summary of the results is listed in Table 5.

On average, patients exposed to an incompatible situation received 10 infusions distributed among 5 lumina. The size of the dots in the bubble charts (Figure 2) is proportional to the prevalence of incompatible situations. The distribution of the points demonstrates a proportional tendencyof incompatible situations (n = 105) according to the number of infusions and the number of lumina. The orange point represents the mean number of infusions and lumens had by the patient, when he or she was exposed to an incompatible situation.

After considering the available lumina and all administered continuous infusions in the 105 incompatible situations, we assessed that for 61 (58%) there may have been an alternative distribution of the infusions by which the incompatible situation could have been avoided.

Results from the logistic regression are presented in Table 6. Associations between patient parameters and exposure to an incompatibility were strongest for the MNIC score. Although no significant association was found for age and PIM, patients who stayed longest were also more frequently exposed to incompatible situations.

Discussion

Our study confirmed that patients hospitalized on our PICU/NICU are exposed to incompatibilities. Although most infusion combinations were compatible, on average at least 1 incompatible situation (n = 105) occurred daily. We found that a limited number of infusions accounted for most of the incompatible situations, many of which could have been theoretically avoided by redistributing the involved infusions among the available lumens. The results from the logistic regression suggest that the major risk factor for exposure to an incompatible situation is the patient's number of infusion combinations. Young age and PIM likely represent

Table 3. Administration of Continuous Infusions

Parameter	Value
No. of catheters per patient per day	
Mean (SD)	2.7 (1.2)
Median (IQR)	3.0 (2.0–4.0)
Range	1–6
CVCs per patient per day	
Mean (SD)	0.8 (0.6)
Median (IQR)	1.0 (1.0–1.0)
Range	0–3
Lumina per patient per day	
Mean (SD)	3.8 (1.8)
Median (IQR)	4.0 (2.0–5.0)
Range	1–8
Infusions per patient per day	
Mean (SD)	6.9 (3.6)
Median (IQR)	6.0 (4.0–9.0)
Range	2–17
Imprecisely documented infusions, no. (%) (total no. = 3949)	370 (9)
Most frequent infusions among all coadministered infusions, no. (total no. = 1447)*	
Morphine	437
Midazolam	363
NaCl 0.9%	251
Noradrenaline	212
Heparin Na	197
Milrinone	149
Furosemide	149
Adrenaline	133
PN	130
GLUC 4.6%–NaCl 0.9%	114
Most frequent pairs of infusions in all coadministered infusions, no. (total no. = 1447)*	
Morphine + midazolam	232
Furosemide + heparin Na	105
Adrenaline + noradrenaline	96
PN + fat emulsion 20%	95
PN + PN	61
Noradrenaline + milrinone	60
Fentanyl + midazolam	58
Morphine + GLUC 9.1%–NaCl 0.9%	44
Morphine + Misch 4:1 10%	42
Morphine + NaCl 0.9%	39

CVC, central venous catheter; GLUC, glucose solution; Misch, solution of glucose and sodium chloride (4:1); PN, parenteral nutrition

* Combinations are composed of 2 or more infusions; therefore, the total no. of listed infusions exceeds the total of incompatible combinations.

Table 4. Combination Types of Infusions

Combinations	No. (%)		
With 2 infusions	1077 (74.4)		
With 3 infusions	301 (20.8)		
With 4 infusions	53 (3.7)		
With 5 infusions	13 (0.9)		
With 6 infusions	2 (0.1)		
With 7 infusions	1 (0.1)		
Total combinations	1447 (100)		
Classification	**Combinations Covered by Internal Charts, no. (%)**	**Combinations From Another Reference Not Featuring in Internal Charts, no. (%)***	**Total, no. (%)**
Incompatible	146 (10)	0	146 (10)
No data	39 (3)	168 (12)	207 (15)
Compatible	1061 (73)	13 (1)	1074 (74)
Variable	15 (1)	4 (0)	19 (1)
Total combinations	1261 (87)	185 (13)	1447 (100)

* Trissel's database and Swiss summary of product characteristics.

surrogates for the severity of the patient's condition and are thereby associated with the number of infusions and lumina.

This study features several strengths. Although many other studies exclude blood products and parenteral nutrition, we considered these administrations as well. In contrast to assessments that simply rely on data as documented in the electronic patient records, evaluating the quality of documentation confirmed that our raw data was representative for the administration of continuous infusions in clinical practice.

With 10% of the infusion combinations classified as incompatible, the proportion of incompatible combinations is apparently higher compared with other previous studies. Gikic et al[11] found a rate of 3.4% in 2000 in another Swiss PICU/NICU. Gaetani et al[12] analyzed administration data from 2006 to 2015 and identified 9% of incompatible intravenous infusion administrations in critically ill children. Other recent studies performed in adult patients exposed to multiple IV drugs have found incompatible combinations in 12% to 56%.[19,20] However, these differences can be explained using different references and methods. Contrary to other similar studies, we did not exclude any drugs or infusions (i.e., we collected data of all continuous infusions, including electrolytes, PN, and blood products). Indeed, the latter two accounted for approximately 50% of all incompatible situations. Furthermore, we recorded data 24/7, albeit without considering injections and short infusions.

In our study infusion combinations were classified looking primarily at the internal compatibility charts. These have been developed by the pharmaceutical services to improve drug administration and patient safety. They cover combinations occurring frequently in clinical practice, even if no primary data on compatibility are available. The internal compatibility charts categorizing certain combinations as incompatible (e.g., because of their extreme pH values, composition of proteins/biologicals, buffers) may be classified as "no data" in other references or studies, thereby increasing the incidence of incompatible situations. The internal compatibility charts allowed the identification of all incompatible combinations and most combinations. Most combinations which were not covered by these charts were also not listed in the other references. However, it is important to note that a combination without compatibility data may be incompatible, especially if the involved infusions feature critical characteristics, such as stabilizers, buffers, solvents, or extreme pH values. Care teams should be trained regarding this potential problem to promote combinations of infusions with favorable compatibility data available.

Among infusions frequently involved in incompatible situations, many feature an extreme pH value. Although an acidic pH is common and may frequently be combined with similarly acidic infusions, infusions such as tranexamic acid or furosemide are alkaline, and as such more likely to lead to incompatibilities. It is therefore important to note that certain acidic infusions, like morphine or midazolam, frequently appear among the infusions involved in many incompatible situations. Yet in most cases, the incompatibility was related to the coadministration of these infusions with alkaline infusions, such as tranexamic acid or furosemide, or generally less stable infusions, like propofol, PN, or blood products. Our analysis of incompatible situations revealed that in many cases there would have been a

Table 5. Incompatible Infusions

Parameter	No. (%)
Incompatibilities	
Incompatible combinations	146
Incompatible situations	105
Oral administration possible	58 (55)
Theoretical compatible lumen distribution	61 (58)
Patients (n = 100) exposed to an incompatible situation	46 (46)
Incompatible infusion combinations (total no. = 146)	
Featuring on internal compatibility charts	146
Thereof also specified in Trissel's*	2
Thereof also explicitly listed in the Swiss SPC	10
Most frequently involved infusions in incompatible combinations (total no. = 146)*	
1. Blood products†	50
2. Midazolam	45
3. Tranexamic acid	34
4. Morphine	32
5. Propofol	23
6. Furosemide	22
7. PN	12
8. Fat emulsion 20%	11
9. Alprostadil	11
10. Clonidine HCl	10
Most frequent incompatible combinations (total no. = 146)*	
1. Blood products‡ + any other infusion	50
2. Tranexamic acid + midazolam	24
3. PN/fat emulsion 20% + any other incompatible infusion	23
4. Tranexamic acid + morphine	22
5. Propofol + morphine	8
Most frequent individual combinations without data on compatibility (total no. = 1447)§	
1. Morphine + GLUC 9.1%–NaCl 0.9%	44
2. Milrinone + GLUC 9.1%–NaCl 0.9%	16
3. Ringeracetat with 1% GLUC + morphine	14
4. Noradrenaline + GLUC 9.1%–NaCl 0.9%	12
5. Furosemide + ranexamic acid	7

GLUC, glucose solution; PN, parenteral nutrition; SPC, summary of product characteristics

* One incompatible combination featured in both references, i.e., Swiss SPC and Trissel's.

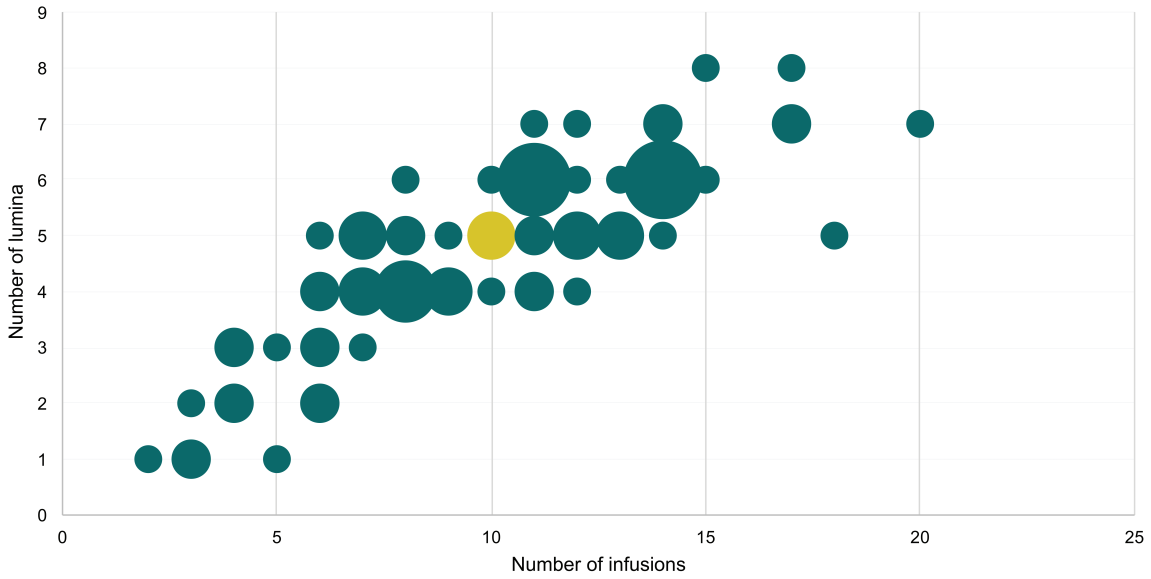
† Incompatible combinations may be due to a combination of multiple infusions; therefore, the total no. of listed infusions exceeds the total of incompatible combinations.

‡ Erythrocyte concentrate, thrombocyte concentrate, fresh frozen plasma, blood plasma, human albumin.

§ Combinations are composed of 2 or more infusions; therefore, the total no. of listed infusions exceeds the total of incompatible combinations.

theoretically compatible arrangement of infusions if they had been redistributed, for example, by combining certain acidic infusions in one lumen to allow more problematic products to be administered separately. Yet, these are academic considerations, which may not fully represent the clinical situation during which the incompatibility occurred. Because of their expertise, members of pharmaceutical services may be able to promote such a preferable distribution of the infusions among the available catheters and lumina, thereby

Figure 2. Incompatible situation according to the number of infusions and the number of lumina.



avoiding incompatibilities or at least minimizing their likelihood if no specific data are available.

Our study also has some limitations: only data from 46% of all patients admitted to the PICU/NICU were considered. We consider it unlikely that the exclusion of patients who refused consent to using their data likely biased our results. And patients who were not included because they had no intravenous coadministrations of continuous infusions were *a priori* not part of the at-risk population. However, we could not consider the IV injections and infusions lasting <15 minutes, and those may likely have further increased the frequency of incompatible combinations. Our categorization regarding the compatibility was limited to 3 chosen references, with the principal reference being internally developed compatibility charts, which limits the generalizability of our results. However, the internal compatibility charts are based on physicochemical properties to promote a safe yet pragmatic coadministration of infusions. Finally, we did not perform a systematic analysis regarding the clinical relevance of the detected incompatible coadministrations because this was beyond the scope of the present study.

Based on our findings, we suggest the following specific measures to further reduce the rate of incompatibilities: (1) discussions and subsequent training with PICU/NICU care teams regarding incompatibilities and the use of the internal compatibility charts, (2) a list specifically designed for the care teams that highlights the most critical infusions (which whenever possible should be administered alone), and finally (3) the addition of a function in the patient data management system software which automatically checks the compatibility of any documented infusion, issuing an automated warning in case of incompatible combinations.

Future research could aim to evaluate these measures—similarly to the introduction of in-line filters, they may serve to reduce the number of severe complications, length of stay, and thereby costs on our PICU/NICU.[6]

Conclusion

The results of this study reveal that incompatible coadministrations of continuous infusions occur daily on the assessed PICU/NICU. The most frequently involved infusions were blood products, PN, emulsions, and infusions with extreme pH values. Sometimes coadministration of formally incompatible infusions is unavoidable because of the limited number of lumina. However, we found that for most incompatible situations an alternative distribution of the infusions among the existing lumens has been feasible.

Given that the internal compatibility charts covered all incompatible combinations as well as most applied combinations, they currently do not require any fundamental modifications. The main action required currently is likely educating care teams about incompatibilities. The pharmaceutical services can and should help improve the patients' safety by promoting an optimal distribution of continuous infusions.

ARTICLE INFORMATION

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Table 6. Results from Logistic Regression

Parameter	OR	SE	z	p value |z|	95% CI
MNIC score					
2–5	11.14	9.50	2.81	0.005	2.08–59.75
6–10	6.13	5.80	1.91	0.056	0.96–39.27
>10	51.81	52.40	3.91	<0.05	7.14–375.74
Age					
21 days to 1 yr	5.26	4.48	1.95	0.051	0.99–27.90
>1 to 3 yr	3.40	2.67	1.55	0.120	0.73–15.87
>3 yr	1.90	1.71	0.68	0.496	0.31–11.26
PIM					
>1% to 2.5%	2.60	2.40	1.06	0.289	0.44–15.72
>2.5% to 5.5%	1.20	1.07	0.22	0.823	0.21–6.78
>5.5%	0.98	0.89	−0.02	0.987	0.17–5.84
Length of stay, days					
1–3	0.77	0.77	−0.26	0.795	0.11–5.44
>3 to 8	1.17	0.98	0.19	0.851	0.23–6.04
>8	11.87	11.53	2.54	0.011	1.76–79.77

MNIC score, maximum number of infusion combinations during the patient's stay in the PICU/NICU; PIM, pediatric index of mortality; z, z score

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